AQUAGUIDE

MISSOURI DEPARTMENT OF CONSERVATION

Operating a Bottom Withdrawal Spillway

This guide describes the operation and maintenance of a unique principal (pipe) spillway for a pond or lake. Operating on the siphon principle, the bottom-withdrawal spillway (BWS) will pass most sediment, suspended organic material and dissolved nutrients through the pond and features an adjustable air vent to allow varying the reservoir water level for weed or wildlife management.

This spillway can also serve extra duty as the withdrawal pipe during the irrigation season (when not required to function as a spillway) by plumbing the discharge end to the intake of a large irrigation system.

An existing hooded or canopy type surface-withdrawal spillway can be converted to a bottom-withdrawal spillway. For design details see UMC Guide 1531.

This spillway should not be used for sediment basins or grade-stabilization structures intended to trap sediment.

Improve Water Quality

The quality of water stored in a reservoir improves with time (between runoff events) as algae and aquatic plants use nutrients, and as algae and suspended sediment are deposited. Conventional surface-discharge spillways permit this cleaner water to be discharged during the next runoff event (Figure 1-A) and to be replaced by surface runoff, which is usually lower in quality (Figure 1-C). The water purification process then begins all over again with the additional new sediment and nutrients trapped in the reservoir.

This process improves the quality of water discharged from the reservoir at the expense of storing the poorest quality water and shortening the useful life of the reservoir (from sediment and nutrient buildup). Good quality water is very important because most food utilized by organisms in the lake is manufactured by algae in the top three to six feet of water.

If sunlight does not penetrate, food and oxygen necessary for good fish growth are not being produced. This production process is slowed by muddy water but gradually increases to the most productive state between runoff events.

If the clear water is retained in the lake, there is no disruption of production.

The bottom-withdrawal spillway allows lower quality storm water to be discharged from the reservoir as soon as it reaches the intake, if the reservoir is full (Figure 2-A).

This inflow will go to the bottom of the reservoir with minimum mixing because it has a higher density caused by suspended sediment, dissolved solids or lower temperature. The water quality of the discharge will be more nearly that of the original stream (prior to construction of the dam) except for sand-size or larger particles that are deposited as the runoff water enters the reservoir. The cleanest water remains in the reservoir because

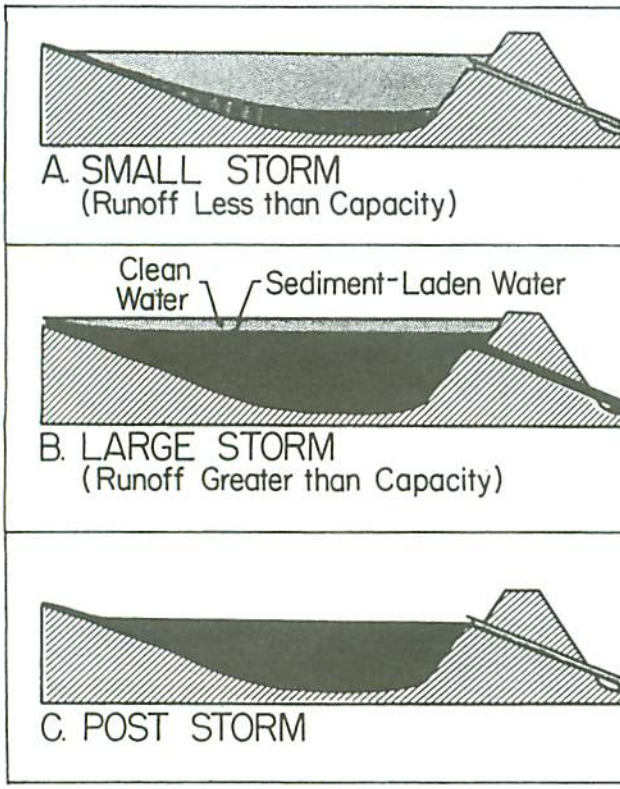

Figure 1. Cross-sectional view of a pond with a surface-withdrawal spillway.

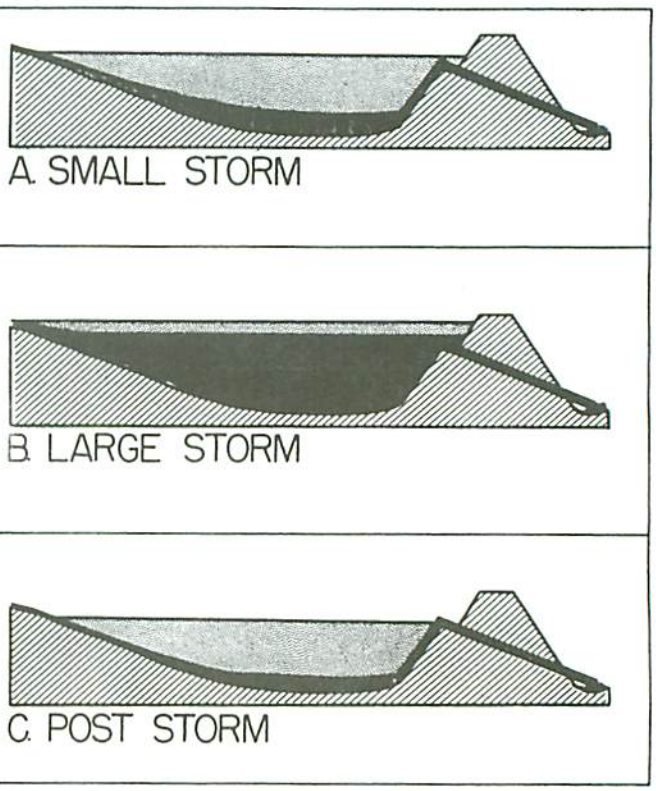

Figure 2. Cross-sectional view of a pond with a bottom-withdrawal spillway.

it is less dense than the inflow and will float up into the "flood storage area" of the reservoir (Figure 2-B).

At the end of most runoff events, the clean water will still be in the reservoir (Figure 2-C). Thus, the quality of the stored water is superior when compared to the muddy water stored in a reservoir with a surface-discharge spillway (Compare figure 2-C and 1-C). Benefits include lengthened reservoir life and better conditions for recreational activities such as fishing and swimming. A major runoff event will result in the loss of good quality surface water if the water level reaches the level of the secondary spillway. If the BWS pipe is large enough, this may not happen often, so use the largest diameter pipe practical.

The normal water level of the reservoir is controlled by the high point of the inside of the pipe (apex). However, if the pipe (siphon) primes, the water level can be drawn down to any desired level, controlled by an air vent with an attached flexible hose. When the water level drops enough, air enters and water flow will cease. This system can be used to lower the water level to control aquatic weeds and improve wildlife habitat.

Sediment Control

Most farm ponds trap 85 to 99 percent of entering sediment. If the pond is intended for clean water storage and recreation, sediment deposition defeats its intended purpose. If sediment is not 100 percent controlled in the watershed, a sediment basin or trap immediately upstream of the pond may be necessary.

Ideally, a sediment basin should be a large, shallow pond with a surface-discharge spillway that skims the cleanest water from the surface. Sand, silt and sand-size aggregates are easily trapped in sediment basins. The remaining suspended clay will flow through the pond downstream and be discharged by the bottom-withdrawal system.

Even a deep, narrow sediment basin is better than none at all. The sediment basin can be either an excavation in the stream channel or a small, above-grade structure. The advantage of the excavated type is that it will return to its natural condition when full. The above-grade type will remain a liability and have to be maintained to prevent failure and mass movement downstream. UMC Guide 1528 describes sediment basins.

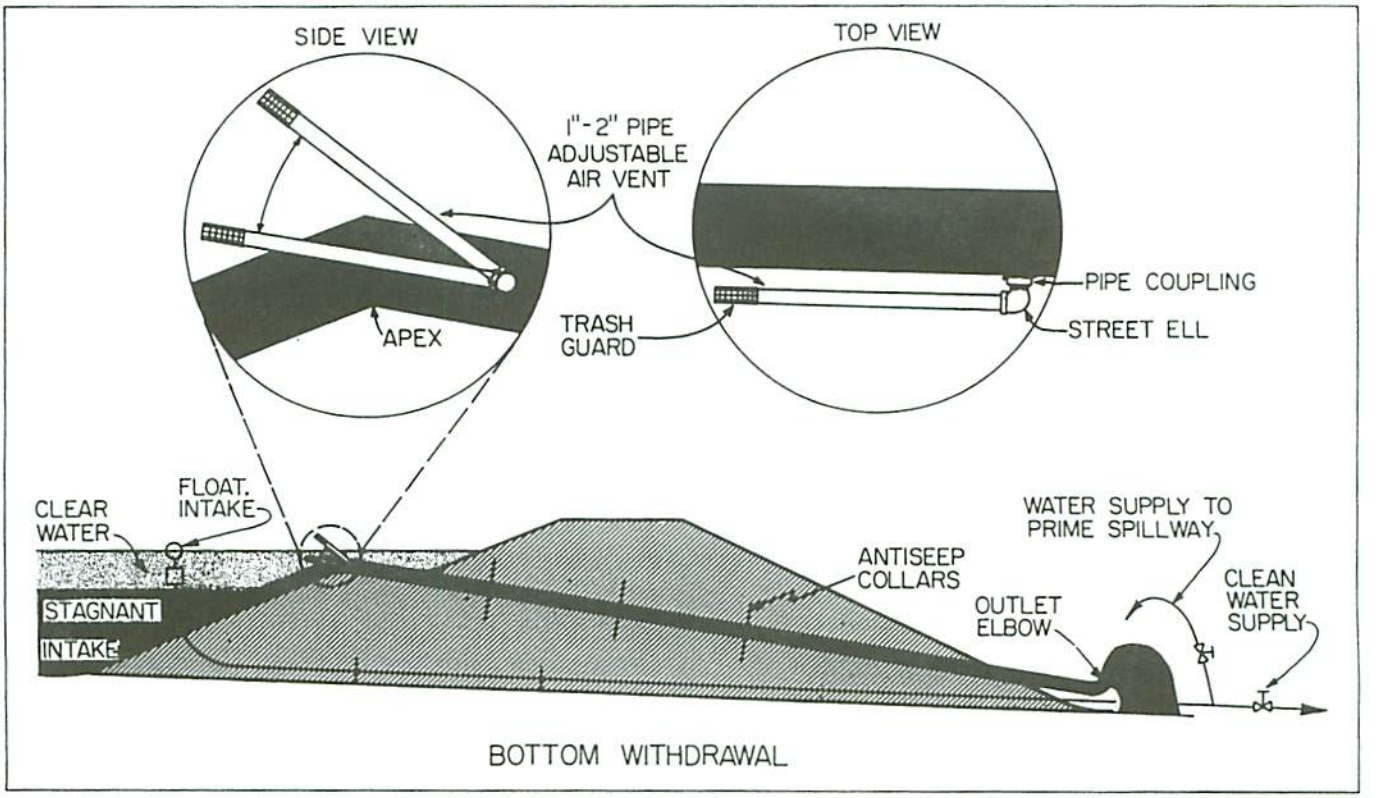

Figure 3. Cross-sectional view of a bottom-withdrawal spillway installation.

Bottom Withdrawal Spillway Features

• Depth of intake: A deep intake not only removes more sediment and nutrients, but also prevents loss of fish. Ponds may develop a zone with little or no oxygen near the bottom during warm weather. Because fish typically won't enter this zone for long periods of time, an intake in the deepest water will lose very few fish from the pond.

• Location of the apex: The elevation of the apex of the pipe determines the normal pool level. However, the apex may be buried in the fill or left exposed on the upstream side of the dam. Burying the apex may be desirable in northern states or when using plastic pipes to prevent ice damage.

• Air vent: The air vent is normally set at the elevation of the apex. If the spillway is manually primed (see priming section below), the air vent can be capped and siphoning will continue until the cap is removed.

• Outlet elbow: The elbow on the outlet end of the pipe serves (1) as an aerator so the anoxic bottom water is aerated as it is released and (2) as an energy dissipator so a deep plunge pool doesn't develop.

• Anti-seep collars: Anti-seep collars are used to prevent water flow external to the spillway pipe. These collars are usually made of steel, plastic, or heavy butyl rubber. For details, see UMC Guide 1515.

Manual Priming

The spillway will automatically prime (flow full and siphon) when the water level rises above the apex if the air vent is submerged or closed. However, there may be times when it is desirable to manually prime the spillway.

The first step is to plug or "stopper" the outlet end. The second step is to fill the pipe with water. This can be done one of three ways: (1) if there is a trickle flow, allow it to fill by itself by leaving the air vent open to the atmosphere; (2) apply a vacuum to the air vent (the vacuum from the manifold of a spark-ignition engine will usually suffice); or (3) attach a hose from a stock water line or other pressurized water source to the downstream end of the pipe or through the plug to fill the pipe.

The third step is to shut off the air vent or clamp the vacuum line. The fourth and final step is to remove the plug from the outlet end and stand back. It is not necessary to remove all the air from the spillway pipe because as the flow increases, the water will remove it.

The water can be stopped manually by opening the air vent. A flexible hose attached to the air vent and laid down the water side of the dam can be adjusted to break the siphon at any desired depth. The pond water level can be lowered to any desired level by lowering the hose opening to that level. The water flow will stop automatically when the water reaches the open end of the hose.

Other Considerations

Water in the bottom of ponds will not cool below 39 degrees F. during winter months. Therefore, if water continues to flow, freezing of the bottom-withdrawal spillway should not occur. However, if the water level of the pond is low when freezing occurs, an ice plug could form upstream of the apex and restrict flow, should a freezing rain produce runoff. This is a rare situation; runoff usually occurs when air temperatures are above freezing.

Plastic pipe may be used for the spillway, but extra care must be exercised during installation. Also, a weep hole should be drilled in the bottom of the outlet elbow to prevent freezing during no-flow conditions in the winter. Remember to plug this weep hole when priming the siphon.

The use of plastic pipe may require rigid protection around it in water less than 3 feet deep to stop damage from ice expansion and to keep wind-driven, floating ice from contacting potentially brittle plastic pipe at break-up. This wall could be steel fence posts driven around the pipe or some similar protective arrangement.

The intake end should be close to the bottom in the deepest water practical. This will maximize the quantity of material passed through the system.

Installation in Existing Impoundments

This system should be fairly simple to install in existing impoundments with no mechanical spillway, because excavation must be only as deep as the desired water level at the water side of the dam with a gradual downward slope to the backside of the dam.

For safety reasons in case of a heavy rain, the excavation could be made and the pipe installed in just the back half of the dam and the pipe buried: Installation of the front half of the system could then proceed, hooking the two halves together in the center of the dam. The pipes down the front and the back of the dam can be angled to the right or left to get them to lay flush with the slope of the soil on each face.

Caution

The potential benefits of the BWS are great, but discharge of poor quality water directly into permanent water may be a violation of State Water Quality Standards. Deposition of sediment downstream on a neighbor is also a possibility, and may create legal liability. Most potential locations should not create these concerns, but if there is any doubt, contact the Missouri Department of Natural Resources prior to spillway installation.

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